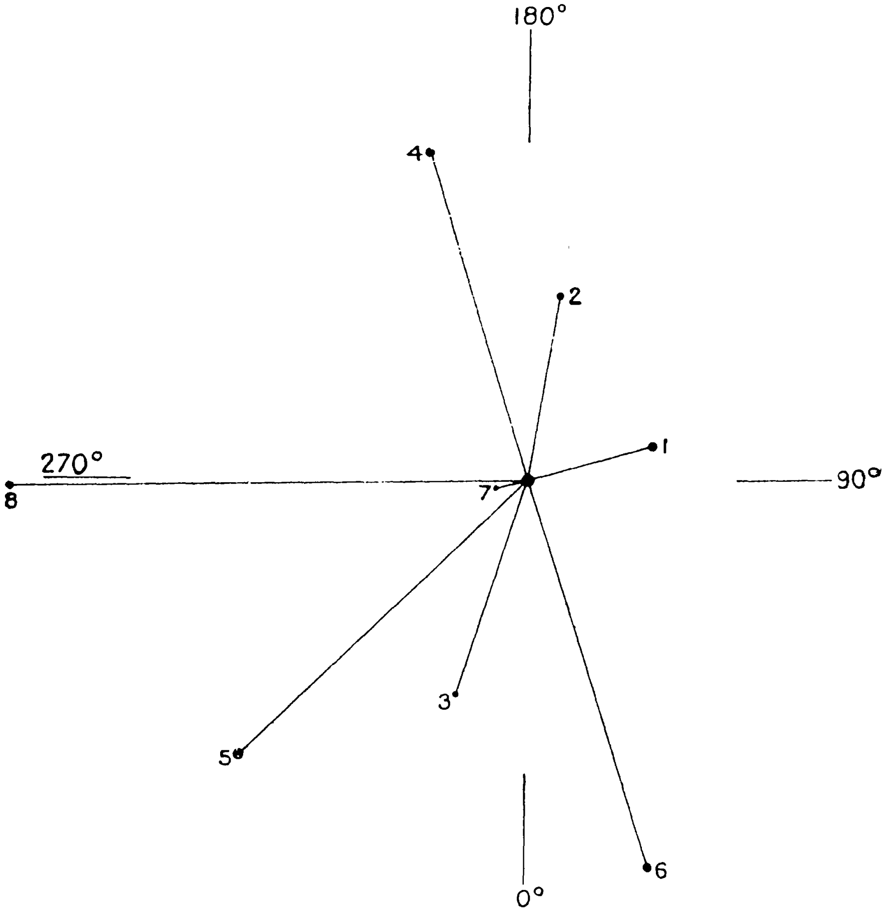
1906MNRAS..66..361F

Nova and 8 (14^m ±).

			°	″
1903	Oct.	26	270·90	131·76
		27	270·83	131·27
	Nov.	16	270·98	131·23
		Mean	270·90	131·42



The accompanying chart of these stars will make their identification easy, even if the Nova should entirely disappear.

High-level Chromospheric Lines and their Behaviour in Sun-spot Spectra. By A. Fowler.

About a year ago I communicated to the Society an account of some spectroscopic observations of the great sun-spot of 1905 February, and of the prominences observed when the spot was on the Sun's limb.* An attempt was then made to distinguish

---

* *Monthly Notices*, vol. lxv. p. 513.

1906MNRAS..66..361F

between high-level and low-level lines in the spectrum of the disturbed chromosphere, and it was pointed out that the high-level lines were not among those intensified in the spot, while the lines common to spots and prominences were chiefly those of iron, chromium, and calcium which appear as strong Fraunhofer lines. Since then I have made numerous observations which furnish additional data for such a comparison; and although the records are not yet so complete as might be desired, the following notes may serve a useful purpose by drawing the attention of observers to some points requiring further investigation, while spots and metallic prominences are still relatively numerous. The Evershed two-prism solar spectroscope has been employed throughout, chiefly in conjunction with the 6-inch refractor at the Royal College of Science, South Kensington, but during 1905 August, in conjunction with a 4½-inch refractor at Castellon, Spain.

Continued attention has been given to the distinction between high- and low-level lines for the reason that Professor Young has not always made this distinction in his well-known list of chromospheric lines, and sufficiently good eclipse photographs of the less refrangible parts of the spectrum are not yet available. When observing the spectrum of a metallic prominence with a tangential slit, the high-level lines are recognised as such by their relatively great length, while the low-level lines are usually very short. In each case the lines are of various intensities, and some of the long lines are faint as compared with the brighter of the short ones. The longest lines of all are, of course, those of hydrogen and helium, but the term "high-level" may be conveniently understood to include all lines which show any considerable extension.

The lines observed on different occasions during the last two years have always been the same, so far as it was possible to determine their positions, and their relative intensities have been nearly constant; those at 5169·2, 5018·6, and 4924·1, however, have shown a certain amount of variation when compared respectively with b_1 and the helium lines 5015·7 and 4922·1.

All the long lines which have yet been noted, but not all the short ones, occur in Young's list, though not many of them are designated as high-level lines. The short lines, so far as they have been identified with terrestrial spectra, correspond with arc lines which are not enhanced on passing to the spark. The long lines, excluding the exceptionally long ones of hydrogen and helium, may be considered as of two varieties: one including the D lines of sodium and the *b* lines of magnesium, which are strong lines both in arc and spark; the other consisting of enhanced lines so far as their origin can at present be traced. Most of these enhanced-line identifications are due to Sir Norman Lockyer,* but my own investigations indicate that at least four

---

* *Phil. Trans.* vol. cxcvii. A, p. 151.

1906MNRAS..66..361F

additional lines are to be assigned to iron, one to titanium, and one to chromium. Full details as to all the lines recorded are reserved until more observations have been secured, but the wave-lengths and intensities of the high-level lines, excluding those of hydrogen, helium, sodium, magnesium, and barium, are given in a table which follows.

The phenomena observed in these disturbances of the chromosphere seem to indicate, as suggested in my former paper and in accordance with the views of Sir Norman Lockyer, that the chromospheric "layers" are elevated without any great disturbance in their order. On this point Lockyer writes :[*] "If the Sun is quiet, or if we observe any particular part of it at any time at which it is not agitated, the layers visible at that time, few in number, are usually concentric, but the moment there is any agitation in the subjacent photosphere the lower layer shoots up into the next layer above it ; the next shoots up into the one next above that ; and so on ; . . . from the very lowest layer to the upper hydrogen one the layers are made to obey this same impulse, and bulge up like so many domes on that part of the Sun which is being violently agitated."

The long lines, whatever their brightness, are more frequently observed than the shorter ones, because it takes a less violent disturbance to bring them into view. The shorter lines, notwithstanding their great brightness in some cases, are only seen on the comparatively rare occasions when the disturbance is sufficiently great to elevate the low-lying flash stratum to such a height that it can be differentiated from the photospheric spectrum. This, at all events, seems to provide a simple explanation of the appearances observed.

It thus appears probable that the metallic prominences yield occasional opportunities of observing the flash spectrum in addition to those furnished by eclipses, and since high dispersion may be employed the positions of the various lines may be determined with the accuracy essential for proper comparison with spot spectra and for purposes of identification.

The additional observations which have been made confirm generally my previous statement as to the relative behaviour of high-level and low-level lines in the spectra of spots, and Mr. W. M. Mitchell, of Princeton, states that his observations are in complete agreement upon this point.[†] Mitchell further observed that some of the high-level lines, so far from being intensified in the spots, are thinned or obliterated. My own observations have confirmed those of Mitchell in this respect and indicate additional examples of the same behaviour. Some of these, and others which I have confirmed by visual observations, are also indicated by the recent photographic records of Hale and Adams.[‡]

---

[*] *Chemistry of the Sun*, p. 169.

[†] *Astrophys. Journ.* vol. xxii. July 1905, p. 40.

[‡] *Ibid.* vol. xxiii. January 1906, p. 11.

1906MNRAS..66..361F

The extent of this thinning or obliteration of lines is possibly somewhat variable from spot to spot, but the varying amount of scattered light, depending on the state of the sky, makes it difficult to ensure certainty on this point. In an observation of the large spot in the south preceding quadrant on 1906 March 27, however, the thinning of the lines appeared to be unusually distinct, and on one or two occasions the line 5169·2 has been seen clearly bright over the umbra. Some of these lines are components of close doubles in the solar spectrum, and the thinning or obliteration then reveals itself as a notch on one side of the compound line where it is crossed by the spot. The iron line 5169·22 with its companion 5169·07 due to iron is one of the best examples; my attention was first drawn to it by Mitchell's paper, and I have since recognised other similar cases.

Particulars as to the approximate intensities of thirty high-level chromospheric lines and of their behaviour in spots are given in the following table. The wave-lengths and solar intensities are from Rowland's tables, and the enhanced-line identifications are Lockyer's, except for those marked F, which result from my own experiments. The prefix "p," as employed by Lockyer, is an abbreviation for "proto," and indicates that the line is relatively enchanced in passing from the arc to the spark spectrum. Under the heading "Spots" the numbers are intensities on the solar scale, except those of Mitchell, which are relative numbers such that -5 indicates complete obliteration. The general behaviour of the lines tabulated suggests that those which are still unidentified will be found to correspond with enhanced lines.

Wave-length.	Origin.	Intensity and Character in Chromos. (F)	Intensity in Sun. (R)	Spots. — (F)	Spots. Hale and Adams.	Spots. Mitchell.	Remarks.
4924·11	*p* Fe	25 *l*	5	Reduced to 3	Out of range	...	...
5018·63	*p* Fe	25 *l*	4	Much reduced	...	5	(1)
5154·24	*p* Ti	15 *l*	2	Reduced to 1	...	...	...
5169·22	*p* Fe	40 *l*	4	Nearly obliterated	·07 } weak on ·22 } red edge	−4	(2)
5186·07	*p* Ti$_F$	10 *l–s*	2	Reduced to 1	...	−3	...
5188·86	*p* Ti	15 *l–s*	2	Reduced	·86 } hazy towards ·02 } violet	2	(3)
5197·74	*p* Fe$_F$	25 *l*	2	Reduced to 0	Reduced to (0–1)	...	...
5226·71	*p* Ti	20 *l–s*	2	Reduced to 1	...	Obliterated once	...
5234·79	*p* Fe$_F$	25 *l*	2	Reduced to 0	Reduced to 1	−3	...
5237·49	*p* Cr$_F$	10 *l*	1	" "	Reduced to (0–1)	−3	...
5264·98	...	15 *l*	0	Obliterated	Reduced to 00	...	...

1906MNRAS..66..361F

Wave-length.	Origin.	Intensity and Character in Chromos. (F)	Intensity in Sun. (R)	Spots. — (F)	Spots. Hale and Adams.	Spots. Mitchell.	Remarks.
5276·17	*p* Fe	35 *l*	3	Not clearly affected	...	Generally not affected	(4)
5284·28	...	25 *l*	1	Nearly obliterated	...	...	(5)
5316·79	*p* Fe	45 *l*	4	Much reduced	...	...	(6)
5325·74	...	15 *l*	2	Reduced to 0	...	...	(7)
5336·97	*p* Ti	15 *l–s*	4	Reduced to 2	...	...	(8)
5363·06	*p* Fe$_F$	30 *l*	3	Much reduced	...	...	(9)
5381·22	*p* Ti	10 *l*	2	Reduced to (0–1)	...	...	(10)
5425·46	...	30 *l*	1	Nearly obliterated	Reduced to (0–1)	−4	...
5527·03	*p* Sc	20 *l*	3	Reduced to 2	...	...	(11)
5535·06	?*p* Fe$_F$	35 *l*	2	Reduced to 1	Reduced to 1	...	...
5991·60	...	15 *l*	2	Nearly obliterated	Out of range	...	...
6238·60	...	15 *l*	2	„ „	„ „	−4	...
6247·77	...	20 *l*	2	„ „	„ „	−4	...
6347·31	...	25 *l*	2	Obliterated	„ „	−4	...
6369·68	...	10 *l*	0	...	„ „	...	(12)
6371·57	...	15 *l*	1	Nearly obliterated	„ „	...	(13)
6432·89	...	25 *l*	1	„ „	„ „	−4	(14)
6456·60	*p* Fe$_F$	20 *l*	3	Obliterated	„ „	−4	...
6516·31	...	30 *l*	2	...	„ „	...	(15)

Remarks.

1. A close double in Sun, Ni 5018·46 (1) and *p* Fe 5018·63 (4). The line is distinctly notched on red side.

2. A close double in Sun, Fe 5169·07 (3) and *p* Fe 5169·22 (4). Notched on red side, as first described by Mitchell.

3. A close double in Sun, *p* Ti 5188·86 (2) and Ca 5189·02 (3). Notch on violet side observed with difficulty, probably on account of widening of Ca line.

4. A very close double in Sun, *p* Fe 5276·17 (3) and Cr (?) 5276·24 (2). The widening of the chromium line possibly obscures the reduction of the *p* Fe line.

5. Rowland gives origin as Ti, but the line does not appear in Hasselberg's table. It may be an enhanced line, but the dispersion of my photographs does not clearly separate it from adjacent lines.

6. This is "1474 K." The reduced intensity is clearly seen in the reproduced photograph given by Hale and Adams. Young has also noted that the line is "distinctly weakened and sometimes reversed." There are closely adjacent lines at 5316·91 (0) and 5316·96 (2).

7. Young gives the wave-length of the chromospheric line as 5325·4. The reduced intensity of the dark line is seen in Hale and Adams' photograph.

8. The line is distinctly weakened in Hale and Adams' photograph.

9. A close double in Sun, Fe 5362·94 (1) and *p* Fe 5363·06 (3). The line is notched on the red side in spots.

10. Rowland attributes solar line to Fe.

1906MNRAS..66..361F

11. Lockyer attributes this line to *p* Sc in *Roy. Soc. Proc.* vol. lxix. p. 359.

12. Rowland attributes solar line to iron. In my instrument it is too feeble in the Sun to determine whether it is reduced in spots or not, but it is certainly not intensified.

13. Rowland attributes solar line to iron.

14. Rowland gives Fe ? for this line.

15. This line is difficult in my instrument on account of adjacent line at 6516·8; it is certainly not intensified in spots, and I believe that it is much reduced in intensity.

The general result of the comparison is to show that a Fraunhofer line agreeing in position with a high-level chromospheric line, if it be of "proto-metallic" origin, is especially liable to be thinned or obliterated in the spectra of spots. In many cases there is a sufficient agreement among the different authorities as to their behaviour in spots, while for others further independent confirmation is desirable. As indicated in the remarks, however, some of the reduced lines which are noted only in my own observations are confirmed by the photograph of Hale and Adams, though they are not shown in the tables of these observers. Many of my observations have also been confirmed by my assistant, Mr. Shaw.

By way of explanation it might be supposed that the vapours producing the enhanced lines in the chromosphere and the corresponding lines in the Fraunhofer spectrum are chiefly restricted to the higher levels, and that their thinning or obliteration in spot spectra is due to the actual withdrawal of the more elevated vapours from the region directly over a spot. On the other hand, the occasional brightening of some of the lines suggests that the chromosphere retains its continuity over the spots, and is sometimes of more than ordinary brightness. It is possible, therefore, that the reduced intensity is to be accounted for by the umbra not providing a sufficiently luminous background to strongly exhibit the absorption of the high-level vapours, while the lines themselves are rarely of sufficient intensity to appear bright.

Observations are somewhat conflicting as to the continuity or otherwise of the chromosphere over spots. Young writes:* "Respighi asserts (and the most careful observations we have been able to make confirm his statement) that, as a general rule, the chromosphere is considerably depressed immediately over a spot. Secchi, however, denies this." Further investigation of this matter is greatly to be desired.

It should be remarked in conclusion that there are many lines which are weakened in spots besides those to which reference has been made, but neither enhanced lines nor high-level chromospheric lines corresponding with them have yet been recorded. Many of these are probably lines of the "widened and weakened" type described by Mitchell, which, with moderate dispersion, are not clearly distinguishable from thinned or obliterated lines.

---

* *The Sun*, 1901 ed., p. 216.

1906MNRAS..66..361F

The most definite conclusion indicated by the observations is that enhanced lines of iron, chromium, and titanium appear as high-level lines in the chromosphere, and that the corresponding Fraunhofer lines are generally enfeebled in the spectra of sun-spots.

[NOTE, April 28.—In *Bulletin* No. IV. of the Kodaikánal Observatory, received since the above paper was read, Mr. Michie Smith records two observations of the obliteration of 6247·77, one of 6347·31, and one of a line at 6084·32. It is interesting to note that the latter is described by Young as a faint high-level chromospheric line, though it is not yet included in my list.]

The Partial Eclipse of the Sun 1906 February 22, observed at Adelaide. By Sir Charles Todd, K.C.M.G., F.R.S.

(*Extract from a letter to A. M. W. Downing.*)

We observed the eclipse as follows :—

	h m s	
First contact	5 58 58	Considered good.
Last contact	6 58 42	Not good, Sun too low and limb very badly defined.

Adelaide standard times ($9^h\ 30^m$ East) of February 23.

Observatory, Adelaide:
1906 *February* 26.

On the Part played by Contrast in the Appearance of the Dusky Areas of Mars. By E. M. Antoniadi.

In his valuable "Observations of *Mars*, 1903" (*Monthly Notices*, vol. lxv. No. 8, June 1905, p. 840), Major P. B. Molesworth, R.E., has written that if my theory of contrast be "pressed to extremes it becomes a most dangerous argument. If we carry it to its logical conclusion we shall have a *Mars* deprived of all 'nuances' of light and shade, both light and dark markings being broad masses of uniform tone unrelieved by any half-tones or delicate shading."

Now in reply to this it is perhaps unnecessary to remark that any physical hypothesis is destined to account for some definite phenomena, and no others. The utility of pressing a theory to extremes is therefore questionable to my mind. At the same time Major Molesworth's "logical conclusion" from